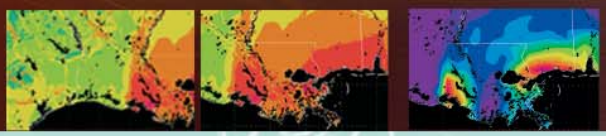
National Aeronautics and Space Administration

Innovations in the 21st Century



2005 Annual Report
to the Administrator by
the NASA Inventions and
Contributions Board

An image of the center of the Omega Nebula, observed April 1 and 2, 2002, by the newly installed Advanced Camera for Surveys (ACS) aboard NASA's Hubble Space Telescope.

Message from the Chair

The message from NASA's engineers and scientists reflects our dedication to producing imaginative solutions in order to achieve our mission goals.

The Inventions and Contributions Board (ICB), overseeing its 47th year of operations, has rewarded 854 unique technologies in FY 2005 and granted 2,917 individual cash awards to our talented scientists, engineers, mathematicians, and software designers for significant scientific and technical contributions to the Nation's aeronautics and space activities.

These Space Act awards provide peer recognition while reflecting the Agency's pride in the awardees and their accomplishments.

The Board congratulates those whose inventions hallmark the beginning of the 21st century and add to the wealth of our Nation.

Chris Scolese, NASA Chief Engineer, ICB Chair

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Introduction and Background

When NASA began to face the challenges placed upon it by Congress and the American people upon its creation in 1958, the Inventions and Contributions Board, also chartered by the Space Act, chronicled the scientific and technical achievements of those who conquered the tasks. This effort is continuing unabated to the present day.

As we learn more about our universe, we realize that the knowledge we have gained merely scratches the surface of the unknown questions that remain. Each day, NASA engineers and scientists document, in the form of invention disclosures, the solutions that have been found in the quest to meet our mission goals.

Last year, 1,735 inventions, nearly five per calendar day, were reported to NASA's system for acquiring and protecting our intellectual property. As a vital aspect of that system, the ICB presented 854 unique new technologies (987 total) with Space Act awards last year. These included:

- 131 patent applications,
- 253 software releases,
- 400 NASA Tech Briefs publications, and
- 203 Board Action cases.

Of the 203 Board Action cases, eight were deemed to be Exceptional in status (as measured and confirmed by peer review and the Board) and 51 were rated as Major cases. The Exceptional cases are highlighted in this report and abstracted for your information. Exceptional cases must have at least one innovator who has received at least $5,000 for the contribution made in the creation of the new technology. Major cases involve payments over $2,000 to at least one of the innovators.

Since 1990, NASA has honored the creators of 154 Exceptional technologies, derived from 22,892 inventions reported in the same period.

Note that each of these thousands of ideas is a unique and innovative solution to problems that we have faced in exercising aeronautics and space activities and conducting research and development in virtually every field of inquiry.

NASA has spent about $200 billion in this same time frame on all our missions and supported hundreds of thousands of engineers and scientists all over the world in our endeavors. This degree of productivity has brought about a sea change in technology during this same historical era.

This year's inventions carry on the NASA tradition of innovation and spark the new millennium with flashes of light guiding our path into the future.

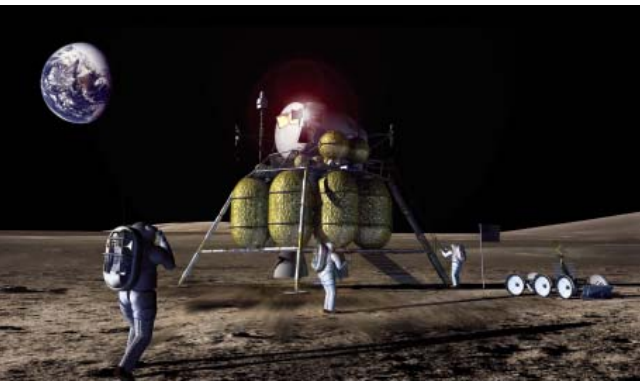
Above: CEV rendezvous with International Space Station.

Challenges of the 21st Century

While we continue to build upon the successes of earlier missions, the President has issued new challenges for us to overcome in the coming years. First, we are expected to return to the Moon and develop long-term human habitats within a lunar colony. We are asked to prepare the way for manned missions to Mars and to eventually create human habitats for long-duration stays on the Red Planet.

NASA is restructuring its assets in order to carry out these new missions. The Space Shuttle is being refurbished to address safety issues but is slated for retirement before FY 2011. Robotic and Earth observing satellite missions continue to be executed, efficiently implementing new technology solutions as a matter of course to maintain cost and schedule constraints.

The development of new systems, including the Constellation and Crew Exploration Vehicle (CEV), will build upon the knowledge, expertise, and design experience from the Shuttle and Apollo-era technologies. We will need much, much more to provide safe manned missions of long duration.



Left: CEV Lunar mission.

Software now pervades nearly every system we build and has become the lynchpin for the success of new missions. NASA's Software of the Year competition, the world's largest award for software excellence, is led by the ICB and cosponsored by the Offices of the NASA Chief Engineer, Chief Information Officer, and Safety and Mission Assurance. NASA invites teams from all over the world to show their wares to prove that they have the "right stuff" in the software development arena, and that the products meet and exceed our standards for quality, efficiency, usability, impact, and innovation. Three of this year's Exceptional awards were won by the technologies offered for the competition.

Materials have become enabling technology in making possible new missions and new scientific discoveries. Four of this year's Exceptional technologies come from the materials genre. The winner of the NASA Government Invention of the Year (also cosponsored by the ICB with the NASA General Counsel) is the braided carbon rope seal. This is the highest temperature seal known to exist, good to 3,000 ˚C. LARC RP46 is the highest temperature hydrocarbon-based material in existence and the winner of the NASA Commercial Invention of the Year. These two are representative of the remarkable achievements in this field made by NASA innovators.

These and other inventions will allow NASA to "invent" the way to solve the problems we will face in 21st century missions.

Innovations, Solutions, and Opportunities

The ICB's peer review of the 854 unique technologies received this year came after internal reviews at host NASA Centers of the 1,735 new technology reports that came in during FY 2005, as well as those of earlier years. Over the past 47 years of our existence we have given over 90,000 cash awards to innovators, and we added 2,917 more awards to that number this year.

Each technology creates new opportunities for American industry to develop jobs, markets, and derivative technologies and ideas that may open new horizons. NASA has been fortunate to publish openly so many ideas in its journal, *NASA Tech Briefs*. Since 1976, *NASA Tech Briefs* has been seen by over 190,000 subscribers and thousands of others who view the monthly publication in libraries and corporate offices around the world. It is one of the most widely read publications by design and production engineers.

NASA Tech Briefs is also published in an electronic edition, and subscribers are encouraged to download technology utilization packages for cases that are highlighted in both editions. Last year, 400 briefs were published and over 25,000 packages were downloaded from the *NASA Tech Briefs* Web site.

The 203 Board Action cases reviewed by the Board yielded many documented incidents of enabled mission successes and commercial introductions of new technology. Among the field of new ideas, the emergence of nanotechnology, materials, software, actuators, and sensors dominate the scene. These "disruptive" technologies that are arriving at NASA's door may completely reshape the landscape and redefine the boundaries of knowledge in a number of fields.

The 131 patent applications awarded this year indicate a strong uptick from prior years. Over 6,500 U.S. patents have been awarded to NASA. That's about one in a thousand that have ever been awarded since 1790 by the U.S. Patent and Trademark Office.

The 253 software releases this year set a new NASA record. Given the extraordinary standards we have set for quality, testing, and documentation, this level of performance is nothing less than remarkable. Mission successes this year are testimony to the great performance of our software developers. The software NASA creates uses the latest technology and techniques available and extends knowledge through every software package written to support science and engineering efforts.

The Board is thrilled to see that NASA continues to produce at record levels in both numbers and quality. The NASA ICB's Space Act awards, while not the cause of this performance, reflect a measure that can be relied upon as a metric of excellence.

Newest Ideas Disclosed

The ICB also peer-reviewed a number of major cases this year, the most significant of which are identified below.

Composition Of and Method For Making High Performance Resins for Infusion and Transfer Molding Processes

John W. Connell, LaRC
Paul M. Hergenrother, LaRC
Joseph G. Smith, Jr., LaRC

LAR-15834-1

Engine-Airframe Structural System Analysis Tools

Kelly Carney, GRC
Charles Lawrence, GRC

LEW-17767-1

Auto Adjustable Pin Tool for Friction Stir Welding

Jeff Ding, MSFC
Peter Oelgoetz, The Boeing Company/Rocketdyne

MFS-30122-1

Software for System for Controlling a Magnetically Levitated Rotor

Carlos R. Morrison, GRC

LEW-17293-2

System for the Diagnosis and Monitoring of Coronary Artery Disease, Acute Coronary Syndromes, Cardiomyopathy and Other Cardiac Ailments

Todd T. Schlegel, JSC
Brian Arenare, Kelsey Seybold

MSC-23449-1

LMBTRK Software

Nicole J. Rappaport, JPL
Essam Marouf, San Jose State University

NPO-40542-1

PREDICTS

Nicole J. Rappaport, JPL

NPO-40987-1

Discovery of Magnetars: Neutron Stars with Extraordinarily Strong Magnetic Fields

Jahannes Antonius van Paradijs
Tod Strohmayer, GSFC
Jeff Kommers, Massachusetts Institute of Technology
Stefan Dieters, MSFC
Chryssa Kouveliotou, MSFC

MFS-32279-1

Improved Fiberoptic Cable Delay Stabilizer And Cable Measurement System

George F. Lutes, JPL

NPO-19353-1

Perilog: Contextual Search and Retrieval Software Tools

Michael Wallace McGreevy, ARC

ARC-14512-1

Softc: A Very Long Baseline Interferometry (VLBI) Software Correlator

Stephen T. Lowe, JPL

NPO-41072-1

Loss of Control Inhibitor System

Ralph C. A'Harrah, NASA HQ

LAR-16566-1

Alternative Control Scheme

Ralph A'Harrah, NASA HQ

HQN-11305-1

Micrometeoroid Orbital Debris (MMOD) Risk Assessment

James L. Hyde, Barrios Technology (Formerly LM)
Russell Graves, Boeing
Dana Lear, ERC, Inc. (Formerly LM)
Thomas G. Prior, Hamilton Sunstrand (Formerly LM)
Eric L. Christiansen, JSC
Justin H. Kerr, JSC
Jeanne L. Crews, JSC (retired)

MSC-23774-1, 23899-1

CFL3D: A Compressible Navier-Stokes Flow Solver for Aerospace Applications

Robert T. Biedron, LaRC
Christopher L. Rumsey, LaRC
James L. Thomas, LaRC
Sherrie Krist, consultant
W. Kyle Anderson, University of Tennessee

LAR-16717-1

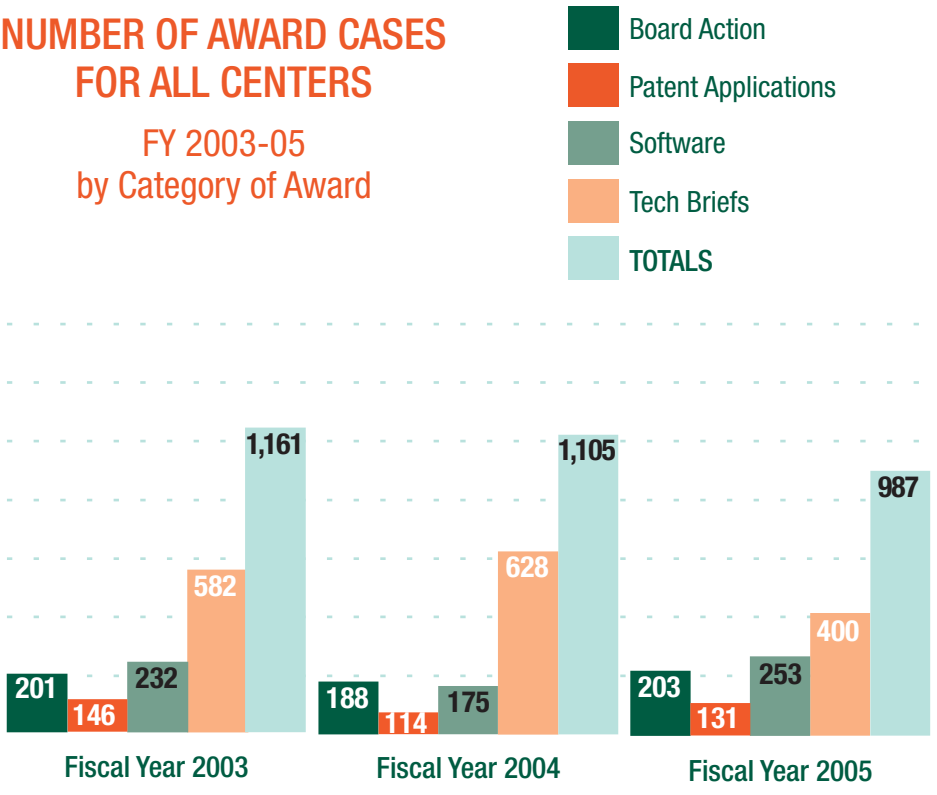
Thermal Imaging Application (TIA)

K. Cramer, LaRC
Fred Hibbard, Lockheed-Martin

LAR-16391-1

NUMBER OF AWARD CASES FOR ALL CENTERS

FY 2003-05
by Category of Award



Exceptional Performance

The eight highest awarded cases for FY 2005 are abstracted below and in the following pages.

Wind Tunnel to Aircraft—Design to Overcome Buffeting

LAR-16515-1

Robert Moses,
Anthony S. Pototzky, LaRC

Sustained and Enabling Contributions to Buffeting Loads Prediction Capability

The contribution is eight-fold: 1) Serving in an advisory role to Lockheed Martin Aero (LMA) to implement a buffet mitigation plan for Joint Strike Fighter X-35 (JSF) so not to repeat cost overruns experienced by F-22 due to tail buffet encountered during flight clearance phase of program; 2) Defining test matrices and providing instrumentation to LMA for measuring buffet on F-22 and JSF wind-tunnel models; 3) Participating in the buffet data reduction during the wind-tunnel tests to guide real-time and proper assessment of the buffet investigation; 4) Scaling wind-tunnel measurements to aircraft flight conditions so that subscale buffet pressures could be used for making aircraft predictions; 5) Incorporating the scaled values into mathematical models of the aircraft's structural airframe and aerodynamics; 6) Using the mathematical models to predict horizontal and vertical tail buffeting for a number of flight conditions where past experiences with F-18 and F-22 suggest that buffet will occur; 7) Validating the predictions against very limited flight data existing on F-22 and X-35; and 8) Implementing the prediction capability at LMA so that engineers there could assess, as early as possible following each airframe design update, the horizontal and vertical tail buffeting using new features added within existing software programs.

Inset: Wind tunnel test on X-35 vertical stabilizer.

Left: X-35 in flight.

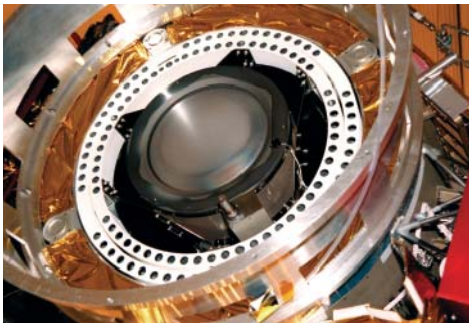
The Modern Ion Rocket for Deep Space Exploration

LEW-11694-1, 11694-2, 11876-1, 12048-1

Bruce A, Banks, GRC

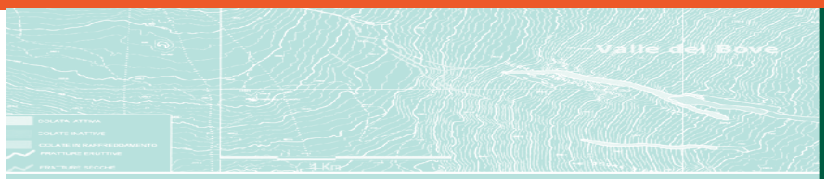
Method of Making Ion Thruster Dished Grids, Hydroforming Apparatus, Methods of Constructing Dished Ion Thruster Grids to Provide Hole Array Spacing Compensation, Anode for Ion Thruster

Since 2002, a 30,352-hour ground laboratory extended life test of the NASA Solar Electric Propulsion Technology Readiness (NSTAR) ion propulsion system has been completed, and was the flight backup of the thruster used on the successful Deep Space 1 mission. Recent analysis of the life tested thruster indicates that the hydroformed ion optics and spall-resistant woven screen anode surfaces of the patents listed performed successfully for a duration of operation of almost double that of the Deep Space 1 mission. The successes of these technologies demonstrated on the Deep Space 1 mission and the extended life test of the Deep Space 1 backup thruster, as well as the favorable post-life test analysis results, have contributed to the confidence that the thruster technologies are appropriately reliable and durable for use on three thrusters for the Dawn mission, which has been approved by the Office of Space Science. The Dawn mission, planned to launch in 2006, will be a three-year electric propulsion flight to visit two large asteroids, Ceres and Vesta, to study the origins of the solar system. Thus, this mission will also use the patented hydroformed ion optics and spall-resistant woven screen anode surfaces technology. In addition to the Dawn mission, Project Prometheus has plans to use the spall-resistant woven screen anode surfaces on the large ion thrusters for the Jupiter Icy Moon Orbiter mission. Although the thrusters planned to be used for this mission are being developed, all thruster designs plan to use the spall-resistant woven screen anode surface technology to retain thick deposits of sputtered material that prevent the development of conductive flakes. Without the use of this technology, spalled conductive flakes could easily short the thrusters, causing thruster and mission failure.



Above: Deep Space 1 hardware before launch.

Left: Close-up of ion rocket.



Smart Software Enhances Scientific Observations

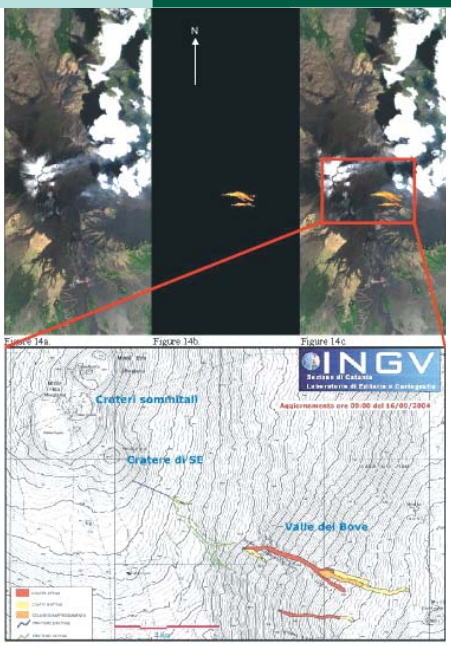
NPO-41993-1

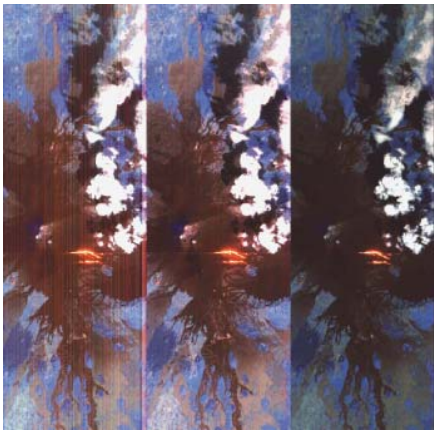
Steve A. Chien, Daniel Q. Tran, Benjamin D. Cichy, Ashley G. Davies, Robert L. Sherwood, Rebecca Castano, Gregg R. Rabideau: JPL; Thomas Doggett, Ronald Greeley: Arizona State University; Seth Shulman: Honeywell; Darrell Boyer: Interface & Control Systems; Bruce D. Trout: Microtel; Stuart W. Frye: Mitretek Systems; Felipe Ip, Victor R. Baker, James M. Dohm: University of Arizona.

The Autonomous Sciencecraft Experiment (ASE) Software

Cowinner
2005 NASA Software of the Year

ASE enables science-driven autonomous spacecraft to increase its science return by two orders of magnitude. It accomplishes this efficiency by autonomously detecting and tracking dynamic scientific processes, and has been successfully used on the Earth Observing One (EO-1) mission. ASE is a new approach to space exploration: instead of relying on ground operations, a spacecraft can now respond autonomously to detected science events. Monitoring of volcanic activity and flooding from space is greatly improved using ASE, thereby impacting mankind as a whole. ASE is in development for use on the NASA/JPL Mars Odyssey mission, and is under consideration for numerous future NASA missions. This technology has been the subject of many journal articles and conference presentations. The value added to NASA has already reached millions of dollars and will undoubtedly increase as ASE is integrated into future missions. ASE is now the primary mission operations software for EO-1. It has flown since January of 2004 and became fully operational in November of 2004. ASE is a product of the groundbreaking patented software system known as ASPEN. ASE is the cowinner of the 2005 NASA Software of the Year competition.





Above: Images from space of Mt. Etna in Sicily during a recent eruption. EO-1 was automatically drawn to view the volcano by the presence of the heat signature from the lava flows.

RP46: Extraordinary Space Age Plastic

LAR-14639-1

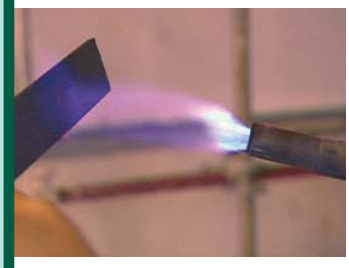
Ruth Pater, LaRC

Low Toxicity High Temperature PMR Polyimide (RP46)

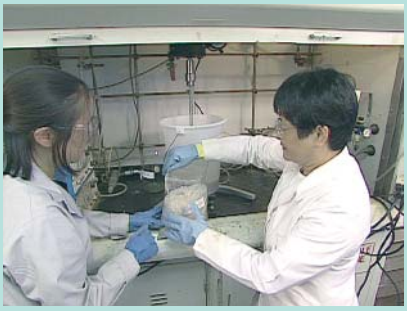
NASA's Commercial Invention of the Year for 2004

LARC RP46 is under evaluation for applications in reusable launch vehicles, space exploration systems, advanced aircraft engine components, and numerous other aerospace and nonaerospace programs. The NASA Exploration Initiative "High temperature composite adhesives for reduced mass aeroshells" project selected RP46 over other materials. The project's goal is to incorporate state-of-the-art materials into aeroshells with decreased structural mass and increased payload for exploration activities. RP46 is selected as the 2004 NASA Commercial Invention of the Year.

An eastern U.S.-based firm is mass producing proprietary components manufactured from LARC RP46 resin provided by Unitech, LLC. The eastern U.S.-based company is a manufacturer of high-performance mechanical products that are used as original equipment and/or specified as replacement parts by the manufacturers of nearly every military and commercial aircraft operating in the world today and a wide variety of military, space, hydropower, and select industrial applications. The product is currently used on a commercial aircraft. It is one of 11 product items that the company seeks to fabricate from LARC RP46. From July of 2003 to July of 2004, Unitech supplied more than 1,300 pounds of the LARC RP46 polyimide resin materials to this manufacturer, representing more than $250,000 in commercial sales. The technology has been selected for missile radomes and structures via a confidential agreement that precludes revealing their names, but acceptance of the LARC RP46 resin system has been widespread. LARC RP46 with carbon fiber reinforcement enhances the entire missile structure. Unitech anticipates that significant production quantities of LARC RP46 will be required to fill the demand for the material beginning in mid-2005.



ONERA, the French National Aerospace Research Establishment, has been evaluating the powder version of LARC RP46 since early 2002. They have also begun to test the liquid version of the resin system. ONERA's goal is to compare the properties of LARC RP46 to a similar high temperature matrix resin for possible recommendation to all French industry. Unitech, through its relationship with California-based pre-pregger YLA, Inc, has supplied composite prepreg samples to ONERA. Unitech's proactive marketing efforts include promotion of LARC RP46 internationally via internet marketing, advertising, and trade shows. Unitech is an



annual participant in the largest composite-based international exhibition, the JEC, that is held each spring in Paris. Worldwide interest in LARC RP46 continues to expand with sample evaluation programs beginning at Formula One Racing Car manufacturers such as Ferrari, Williams F1, Porsche, and Jaguar. Unitech is in the process of obtaining an export license for LARC RP46. Domestically, Unitech exhibits at Society for the Advancement of Material and Process Engineering (SAMPE) each year and recently has been included in the various invitation-only, High Temple events held throughout the year. High Temple seeks to advance new, high technology, high performance materials such as LARC RP46 within the aerospace community. Unitech recently enhanced its laboratory facilities with the addition of Differential Scanning Calorimeter (DSC), a Thermogravimetric Analyzer (TGA), a High Performance Liquid Chromotography (HPLC), a high capacity Quincy Precision Oven with temperature range to 538 ˚C and a 50-ton Wabash heated platen press. These additions, while reinforcing Unitech's long-term commitment to the commercialization of LARC RP46, have allowed the company to establish itself as the source for consistent, quantifiable, reliable high temperature materials and technical support thereof. The aerospace and nonaerospace communities are rapidly moving to implement LARC RP46 as a low toxicity replacement material for the current state-of-the art, high temperature resin. Firms such as Boeing, Northrop Grumman, General Electric, Lockheed Martin, United Technologies, and others have all conducted internally funded research and development on the technology. Emerging systems such as the next generation reusable launch vehicle, F-22, Joint Strike Fighter, and many other defense and commercial systems will contain components manufactured from LARC RP46, which is NASA's Commercial Invention of the Year for 2004.

Opposite top: Parts made from RP46.

Opposite bottom: A flame test.

Above left: A powder test.

Above center: A fluid test.

Above right: A characterization test.

Seals for Rocket Engines Made from Carbon

LEW-16684-1

Bruce Steinetz,
Patrick H. Dunlap, GRC

2004 NASA Government Invention of the Year

Rocket Motor Joint Construction Including Thermal Barrier

This unique, braided carbon-fiber thermal barrier is designed to withstand the extreme temperature environments in current and future solid rocket motors and other industrial equipment. The new, highly reliable thermal barrier was developed for several critical nozzle joints on the Space Shuttle solid rocket motor. The thermal barrier is a revolutionary development that provides an elegant solution to overcome a vexing problem of protecting temperature sensitive O-rings required to seal 60 atmospheres and over 3,000 ˚C combustion gases (see cover). The new thermal barrier represents a significant improvement over the current joint-fill approach which, on occasion, allows hot combustion gases to penetrate through to nozzle joint O-rings. In the current design, 1 out of 15 Space Shuttle solid rocket motors experiences hot gas effects on the Joint 6 wiper (sacrificial) O-rings. Also worrisome is the fact that joints have experienced heat effects on materials between the room temperature vulcanized (RTV) rubber and the O-rings, and in two cases O-rings have experienced heat effects. These conditions lead to extensive reviews of the post-flight conditions as part of the effort to monitor flight safety. This important new technology promotes Shuttle and astronaut safety and enables solid rocket motor joint assembly in one-sixth the time of previous approaches with much higher degrees of reproducibility. Another recent success story further illustrates the impact of the new thermal barrier technology. Lockheed-Martin contracted Aerojet to build the solid rocket motors for the Atlas V Enhanced Expendable Launch Vehicle (EELV). In the spring of 2002, Aerojet experienced a major failure of their solid rocket motor during a qualification test. In that test, hot combustion gas reached the nozzle-to-case O-rings (prior to the addition of the thermal barriers), causing a major structural failure that resulted in the loss of the nozzle and aft dome sections of the motor. Aerojet undertook an aggressive redesign effort to include the Glenn Research Center (GRC) thermal barriers in the joint design. They performed two successful qualification tests (October and December 2002) in which three Glenn thermal barriers blocked the searing hot 3000+ ˚C pressurized gases from reaching the temperature sensitive O-rings. These successful qualification tests put the Lockheed-Martin/Aerojet team back on schedule for meeting an aggressive launch schedule. The GRC thermal barriers have since enabled successful flights on two Atlas V commercial launches. The thermal barrier and nozzle joint construction approach presented is mission-critical to the Atlas V Launch Vehicle. This is selected as the 2004 NASA Government Invention of the Year.

Above: Arcjet testing of the ultra-high temperature rope seals invented by Steinetz and Dunlap for use on solid rocket boosters (SRBs). The braided carbon fiber seals hold back gasses at 60 atmospheres and over 3000 ˚C.

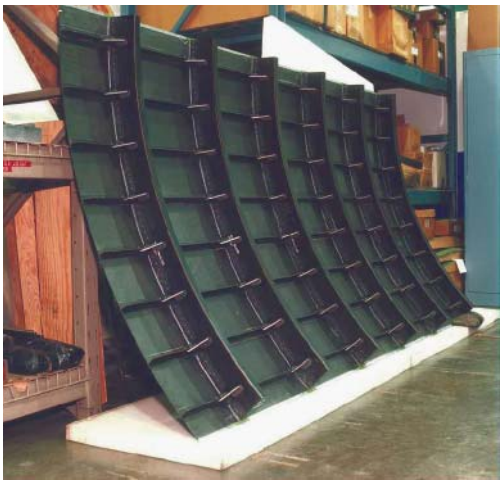
Ultra-High Temperature Adhesives and Epoxies

LAR-15449-2

Brian Jensen, LaRC

Method to Prepare Processable Polyimides with Reactive Endgroups Using 1,3-Bis (3-Aminophenoxy) Benzene

This invention is for a new class of high performance, high temperature resistant adhesives and composite matrix materials that are easily processed into useful structures. They have an exceptional combination of high mechanical properties, high use temperatures, and ease of processing that make them unique, novel, and advantageous for many aerospace, as well as nonaerospace, applications. New chemistries were discovered that provided novel polymeric materials with reactive endgroups (including ethynyl, phenylethynyl, nadic, and maleimide) that provide a unique combination of mechanical and thermal properties and ease of processing into useful structure. The phenylethynyl terminated materials have been evaluated as adhesives and the strengths produced exceed those of the best epoxies available (56,000 kPa tensile shear strength vs 42,000 kPa for epoxies), which are considered to be state-of-the-art in adhesive chemistries. Composites have been prepared and evaluated and their performance exceeds that of bismaleimides, which are considered to be state-of-the-art in high temperature resistant composites that are readily processable. The use of these materials will continue to expand as their unique combination of properties is recognized by industry.



Left: Panels made using the Jensen adhesives for a Boeing aircraft.

Using the Land to Make Better Weather Predictions

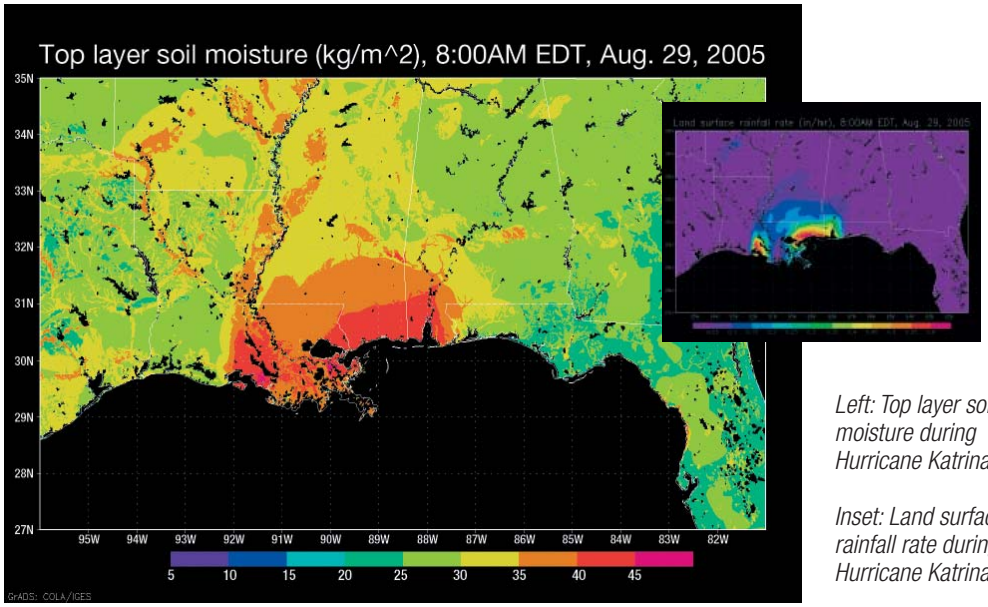
GSC-14997-1

Christa D. Peters-Lidard, James V. Geiger, Jr., Susan P. Olden, Luther Lighty; GSFC; Paul R. Houser; George Mason University; Sujay V. Kumar, Yudong Tian; UMBC-GEST.

Land Information System Software (LIS) V4.0

Cowinner
2005 NASA Software of the Year

The Land Information System software *(http://lis.gsfc.nasa.gov/)* is a high performance land surface modeling and data assimilation system. It integrates parallel and distributed computing technologies with modern land surface modeling capabilities, and establishes a framework for easy interchange of other land surface models. The software includes an ensemble of land surface models and can be run regionally or globally on grids with horizontal resolutions ranging from 2.5 degrees to 1 km. The software may execute serially or in parallel on various high performance computing platforms. In addition, the software developed has well-defined, standard conforming interfaces and data structures to interface and interoperate with other Earth system models. Developed with support from the Earth Science Technology Office (ESTO) Computational Technologies, LIS has helped advance the Earth-Sun division's software engineering principles and practices while promoting portability, interoperability, and scalability. LIS is being used on the science teams for the currently orbiting Gravity Recovery and Climate Experiment (GRACE), the Tropical Rainfall Measurement Mission (TRMM), and the EOS-Aqua Advanced Microwave Scanning Radiometer-EOS (AMSR-E). It is also being prototyped as the software infrastructure to produce level-4 products from the ESSP-3 mission Hydros, to be launched in 2010. LIS is the cowinner of the 2005 NASA Software of the Year competition.



Left: Top layer soil moisture during Hurricane Katrina.

Inset: Land surface rainfall rate during Hurricane Katrina.

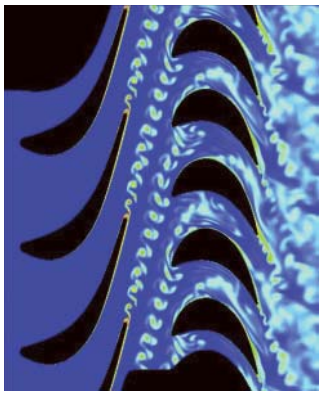
Designing More Efficient Turbomachines

MFS-31622-1

Daniel J. Dorney; MSFC; Douglas Sondak; Boston University.

CORSAIR Three-Dimensional Unsteady Viscous Flow Analysis

A flexible code called CORSAIR has been developed for predicting the flows in rotating turbomachinery components. The code includes modeling that enables its application to jet-engine, rocket-engine, and air-handling. The CORSAIR code has been applied to both new designs and anomaly investigations. The code was applied to the design and analysis of the FASTRAC, Cobra, RS-83 and RS-84 turbine geometries, and is currently being used in the design and analysis of all turbine geometries at Marshall Space Flight Center (MSFC). The code was used to identify vortex shedding as the aerodynamic mechanism causing cracks on the first-stage vane of the Space Shuttle Main Engine (SSME) low pressure oxidizer turbine, as well in the investigation of cracks in the flow liner upstream of the SSME low pressure fuel pump inducer. The CORSAIR code has helped incorporate the effects of unsteadiness and three-dimensionality into the initial design phase of pumps and turbines. This has enabled designs with improved efficiency and durability, and has reduced the need for costly redesigns.



Left: Simulation of unsteady flow inside a turbine.

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